IMPLEMENTING A RISK-INFORMED APPROACH TO DAM SAFETY IN A REGULATORY ENVIRONMENT

David Lord, PE, FERC,
Senior Civil Engineer, Risk-Informed Decision Making Branch

Douglas Boyer, PE, CEG, FERC,
Chief, Risk-Informed Decision Making Branch,
Division of Dam Safety and Inspections

May 16, 2016

Purpose of RIDM

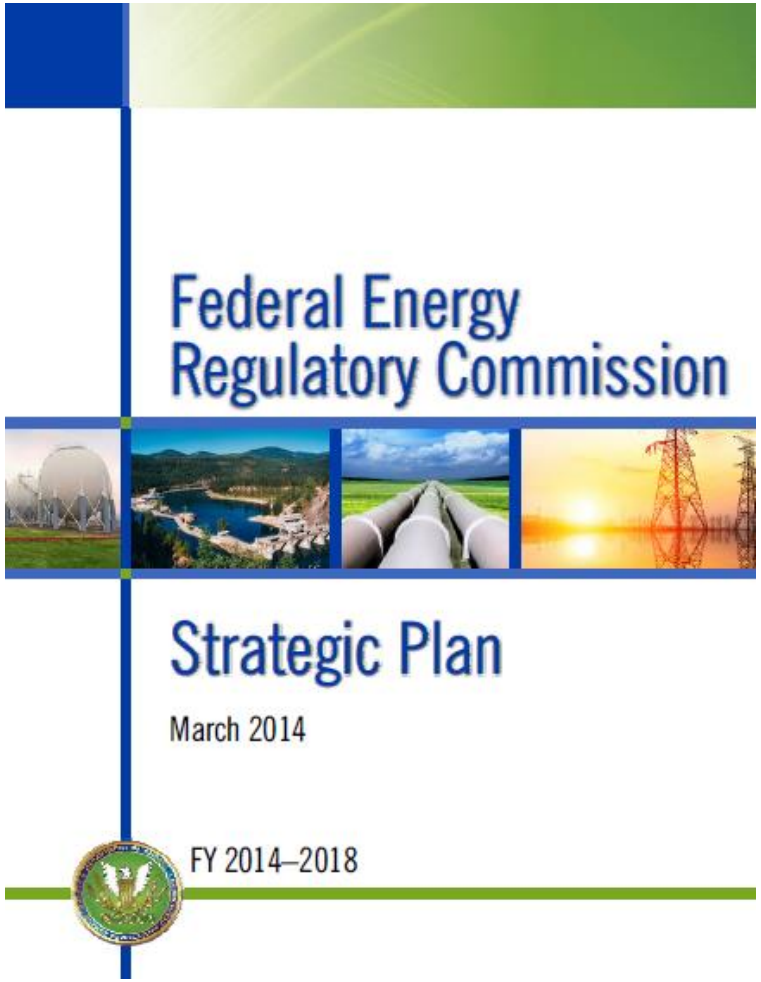
- Fewer Dam Failures
- Make Dam Safety Decision–Making More Effective and Efficient
- Improve Evaluations, Investigations, Remediations, and Monitoring

Outline

- Background
- Overview of Risk Guidelines
- Path Forward

FERC Strategic Plan (2014)

- Goal 2 (of 3)
  - *Promote the development of safe, reliable, secure, and efficient infrastructure that serves the public interest.*
- Objective 2.2 (of 2)
  - *Minimize risks to the public associated with FERC-jurisdictional energy infrastructure.*
- *Strategy 1 (of 3)*
  - *Use risk-informed decision making to evaluate dam safety.*

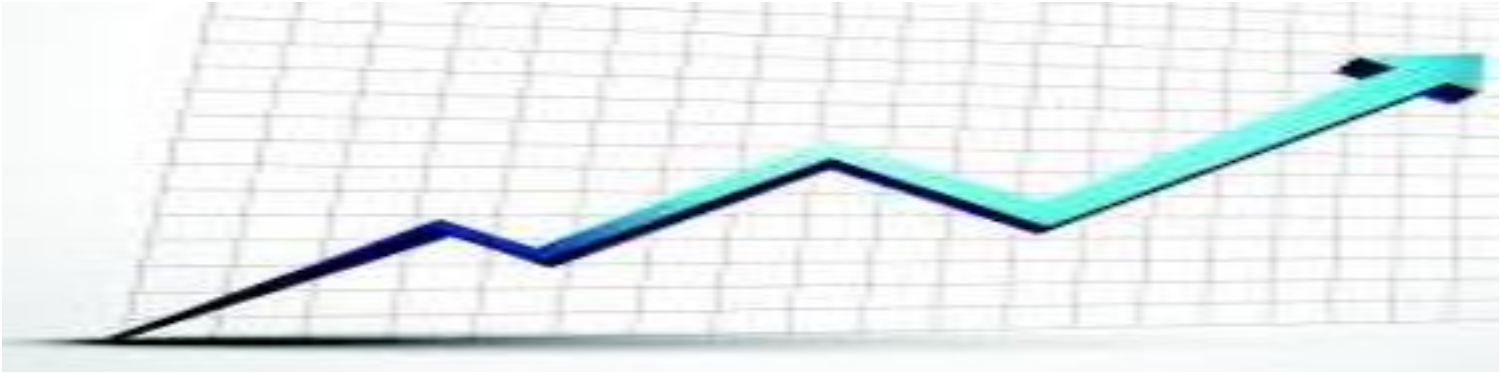


Risk Activities

- Policy/Guidance Documents
- Risk Methodology
- Pilot Studies
- Training

Risk Guideline Status

- In development since about 2012
- Draft guidelines in August 2015
- External review from Sept through Dec 2015
- Draft final guidelines in February 2016
- Final guidelines (interim) posted in March 2016

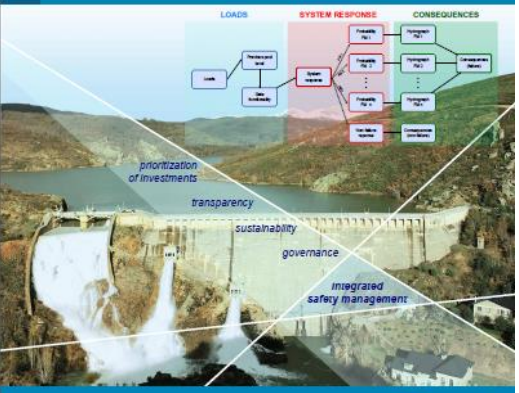


TECHNICAL GUIDES ON DAM SAFETY

P - 8

TECHNICAL GUIDE ON
OPERATION OF DAMS AND RESERVOIRS
VOLUME 1

RISK ANALYSIS APPLIED TO MANAGEMENT OF DAM SAFETY



PROFESSIONAL ASSOCIATION OF CIVIL ENGINEERS

SPANISH NATIONAL COMMITTEE ON LARGE DAMS

ER 1110-2-1156
XX January 2013

US Army Corps
of Engineers

ENGINEERING AND DESIGN

SAFETY OF DAMS - POLICY AND PROCEDURES

ENGINEER REGULATION

Guidance Note on Dam Safety Decision Principles

Department of Sustainability and Environment

DAM SAFETY GUIDELINES 2007

(2013 Edition)

CDA ACB

Canadian Dam Association
Association Canadienne des Barrages
www.cda.ca

Risk Management Policy Framework For Dam Safety

Endorsed by Cabinet
22 August 2006

New South Wales Government
Dams Safety Committee

2007.05.04 15:23:11 +10'00'

RECLAMATION
Managing Water in the West

Interim

Dam Safety Public Protection Guidelines

A Risk Framework to Support Dam Safety Decision-Making

U.S. Department of the Interior
Bureau of Reclamation
Dam Safety Office
Denver, Colorado

August 2011

---

defra

Environment Agency

delivering benefits through evidence

Guide to risk assessment for reservoir safety management

Volume 1: Guide

Report – SC090001/R1

Flood and Coastal Erosion Risk Management Research and Development Programme

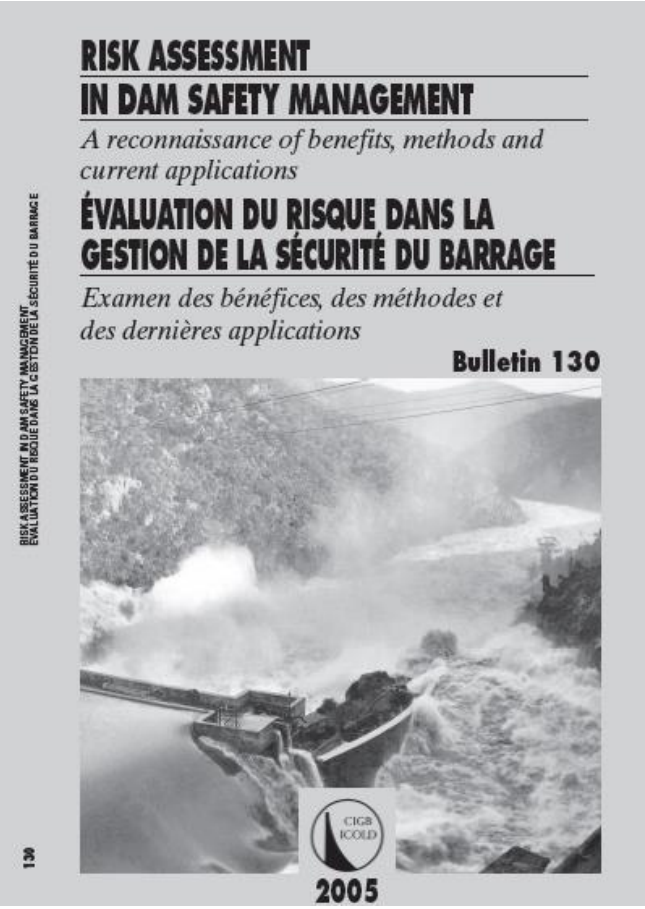
---

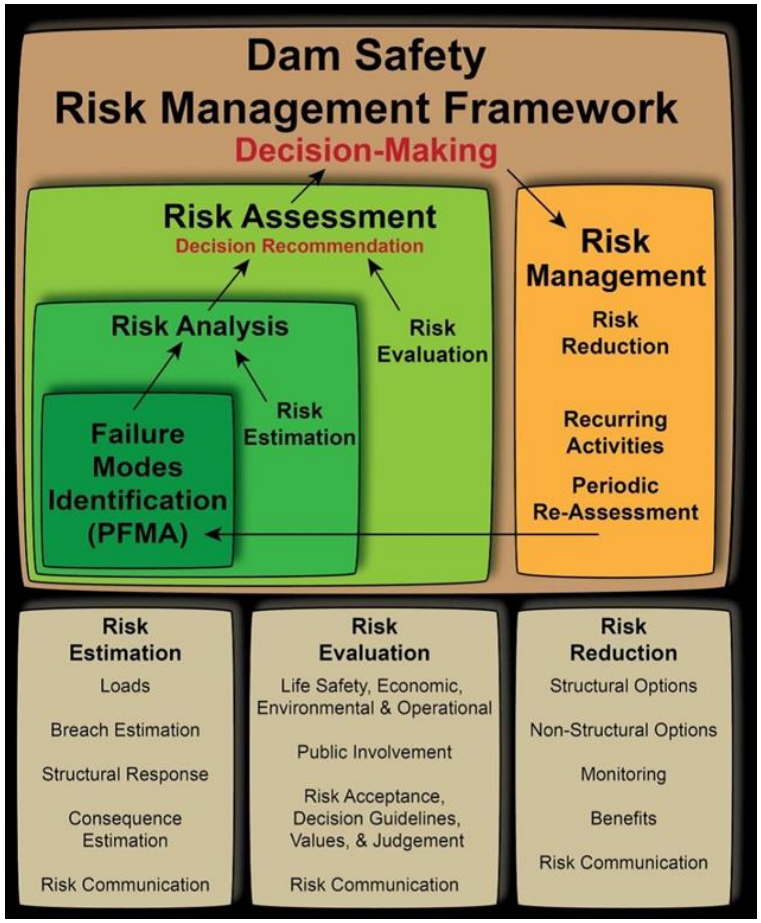
Guidelines on Risk Assessment

October 2003

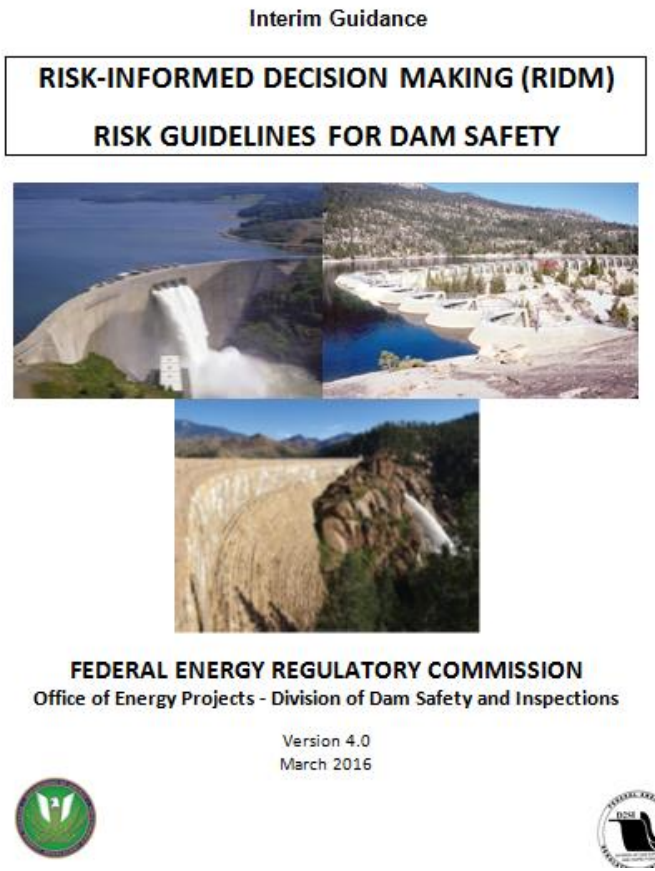
Australian National Committee on Large Dams Inc.

Other Source Documents





RIDM Risk Guidelines



Chapter 1 – Introduction
Chapter 2 – Risk Analysis
Chapter 3 – Risk Assessment
Chapter 4 – Risk Management

Chapter 1 – Introduction to RIDM

- Risk Terminology/Definitions
- Approaches to Dam Safety Assessment
- Owner/Licensee Responsibilities
- Implementing RIDM Approaches

Benefits of Risk-Informed Decision-Making

- Better Understanding of Potential Failure Modes
- Identifying Previously Unidentified Potential Failure Modes
- Considering the Probability of Failure & Consequences
- Comparing the Safety of Different Dams
- Understanding the Uncertainty in Analyses
- Comparing the Contribution of All Failure Modes to the Overall Risk

Benefits of Risk-Informed Decision-Making

- Understanding the Risk Associated with an Inventory of Dams
- Evaluating Risk Reduction Alternatives
- Identifying Critical Systems and Components
- Focusing Surveillance & Monitoring Programs
- Improving Emergency Action Plans
- Prioritizing Dam Safety Resources

Benefits of Risk-Informed Decision-Making

- Highlighted Benefits
  - Improved understanding of the safety of the dam
  - A means of analyzing risks in areas where no traditional standards exist
  - Proper understanding of potential liabilities of dam ownership
  - Basis for demonstration of due diligence

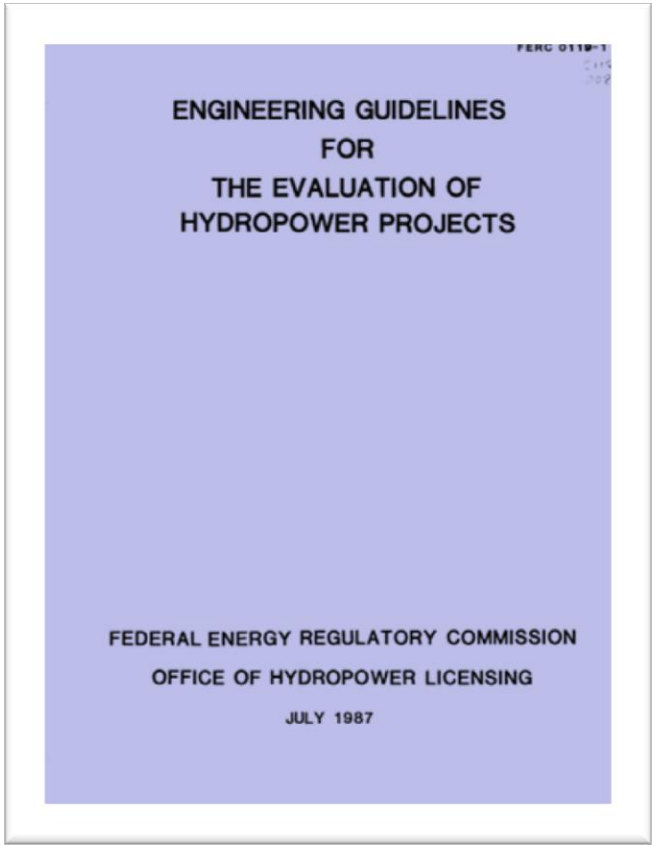
Implementing RIDM

- RIDM **ENHANCES** Standards

There was previously a view by some that risk assessment was a means to justify less costly safety upgrades of dams than those required by the SBA. It is now recognized that such a view seriously misunderstands the true aim of risk assessment, which is more informed decision making than would be possible from reliance on the SBA alone.

How?

- Two ways:
  - Standards-based Approach
    - FERC Engineering Guidelines and established processes
  - Risk-informed Approach
    - Identification, evaluation, and management of risks



Why Not Just Standards?

- Sometimes standards are not enough
- Sometimes standards are not equitable
- Sometimes standards don't provide a proper framework to evaluate safety
- Standards focus on the infrastructure and not so much on the people
- Standards have a tendency to lead to a 'check the box' mentality
- Recognition risk approaches helps in better informed decision making

Chapter 2 – Risk Analysis

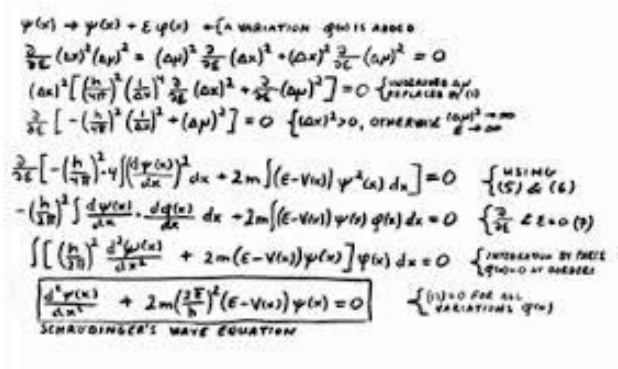
- Elements of risk analysis

Chapter 2 – Risk Analysis

- Types of Risk
  - Incremental Risk
  - Non-breach Risk
  - Residual Risk
- Risk Measures
  - Life Safety
    - Individual risk
    - Societal risk
    - Non-breach risk
  - Annual Probability of Failure
  - Economic
  - Environmental and Other

Chapter 2 – Risk Analysis

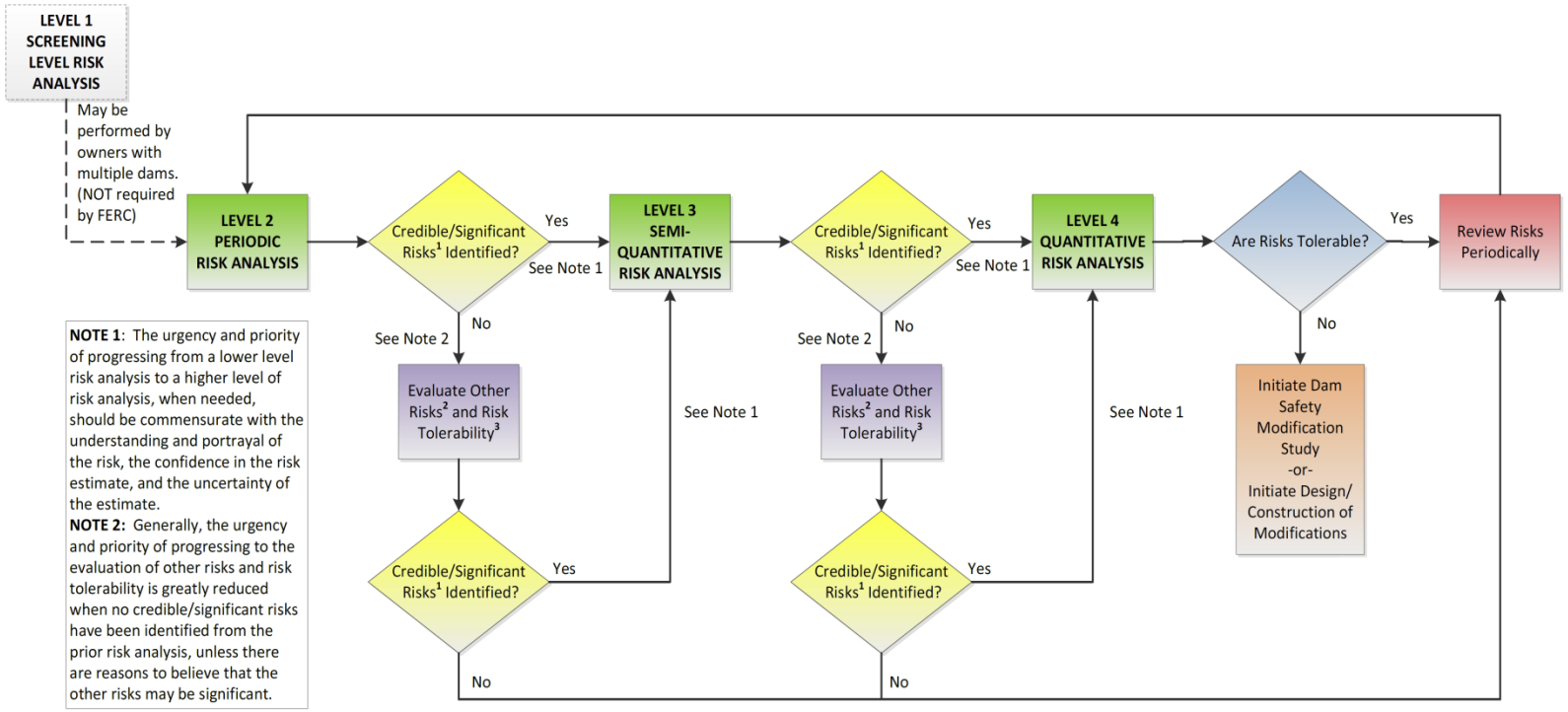
- Levels of Risk Analysis
- Roles and Responsibilities
  - Qualifications of personnel
- Methodology
- ALARP
  - Factors
- Documentation
- Reviews



Levels of Risk Analysis

- Level 1 – Screening
- Level 2 - Periodic
- Level 3 - Semi-Quantitative Risk Analyses (SQRA)
- Level 4 - Quantitative Risk Analyses (QRA)

Risk Analysis Process



NOTE 1: The urgency and priority of progressing from a lower level risk analysis to a higher level of risk analysis, when needed, should be commensurate with the understanding and portrayal of the risk, the confidence in the risk estimate, and the uncertainty of the estimate.
NOTE 2: Generally, the urgency and priority of progressing to the evaluation of other risks and risk tolerability is greatly reduced when no credible/significant risks have been identified from the prior risk analysis, unless there are reasons to believe that the other risks may be significant.

FOOTNOTES:

1. **Credible/Significant Risks** – Risks that are considered unacceptable or intolerable (as defined in Chapter 3)

2. **Other Risks** – Individual risk, non-breach risk and economic, environmental, and other consequences

3. **Risk Tolerability** – Evaluate if risks meet ALARP considerations (as defined in Section 3.3.6 in Chapter 3)

At the completion of each risk analysis:

1. Identify and implement Interim Risk Reduction Measures as identified in Chapter 4 of these guidelines.
2. Review DSSMP/DSSMR for adequacy and frequency of readings.
3. Review EAP for input on warning time and consequence implications.
4. Review annual dam safety inspection frequency, timing, and scope.
5. Review O&M procedures for possible improvements/concerns.
6. Review training requirements and schedule.

Roles and Responsibilities

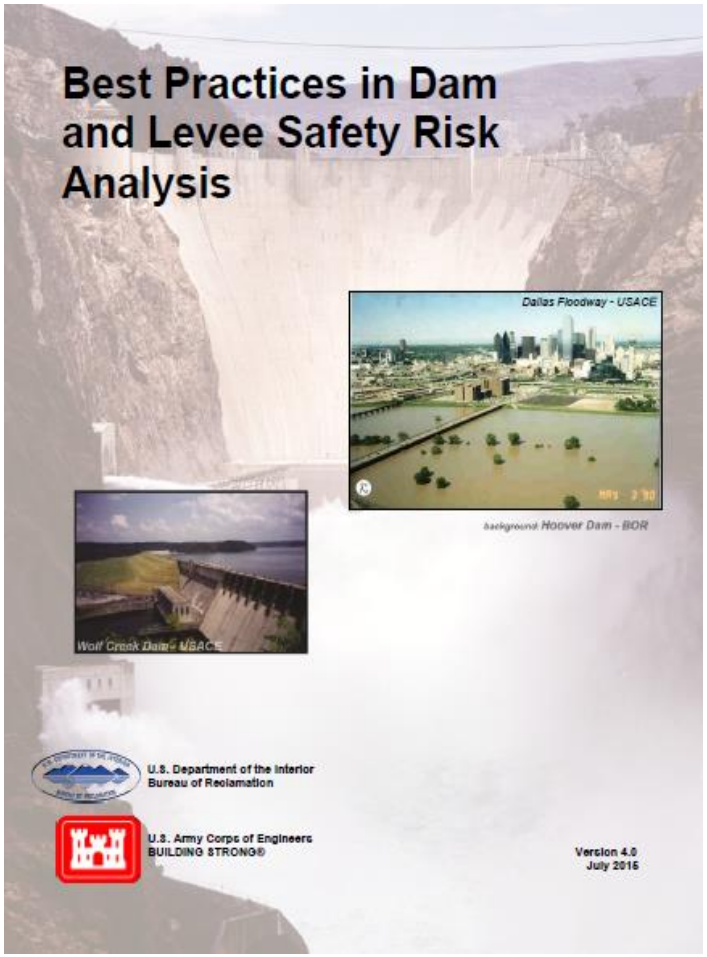
- Facilitator
- Subject Matter Expert
- Software Operator
- Note Taker

Table 2-2. Guidelines for Minimum Qualifications of Key Risk Analysis Personnel

	Facilitator					Subject Matter Expert	Software Operator	Note Taker/ Recorder
	Level 2 Periodic	Level 3 SQRA	Level 4A QRA	Level 4B QRA	Level 4C QRA			
Dam Safety Experience								
Years of dam safety experience (investigations, studies, designs, construction, etc.)	10	10	15	20	20	10	5	5
Primary author on dam analysis, design, or construction (number of technical papers or significant reports authored)		5	5	7	10	5		
Lead reviewer or member on expert panel/board for dam studies, design, or construction (number of projects)					4			
Lead technical role for one or more technical disciplines for dam analyses (number of projects)		2	2	4	4	5		
Author, presenter, or participant in dam failure or incident case history (number of case histories)		2	3	4	5	1		
Risk Analysis Experience (number of projects)								
Participant as a subject matter expert (SME) for a risk analysis		2	2	4	6			
Primary author of Level 3 risk analysis reports			2					
Primary author of Level 4 risk analysis reports				2	2			
3rd party reviewer/independent review of Level 3 risk analysis reports			2					
3rd party reviewer/independent review of Level 4 risk analysis reports				2	5			
Facilitated level 3 risk analyses			2					
Facilitated level 4A risk analyses				2				
Facilitated level 4B risk analyses					2			
Primary author of a technical publication on dam safety risk analysis					2			
Training*								
Base Courses								
Overview of Risk Analyses	R	R	R	R	R	R	R	R
Best Practices in Dam Safety Risk Analyses		R	R	R	R	R	S	S
Level 2 Risk Analyses	R							
Level 3 Risk Analyses		R	R	R	R	R		
Facilitation			R	R	R	S		
Loadings and Consequences								
Hydrologic Loading		S	S	S	R	R		
Seismic Loading		S	S	S	S	R		
Consequences		S	S	S	R	R		
Failure Modes and Risks								
Internal Erosion Mechanics					S	R		
Internal Erosion Risks					S	R		
Overtopping/Overwash/Erosion of Soil and Rock					S	R		
Seismic Analysis of Concrete Structures and Gates					S	R		
Seismic Analysis of Embankments					S	R		
Operational Risks			S	S	R	R		
Risk Analysis								
Failure Modes and Event Tree Construction			S	R	R		R	
Risk Analysis Software Tools			S	R	R		R	
Portrayal of Risks to Support Decisions			S	R	R			
Other								
Professional License Requirements	PE	PE	PE	PE	PE	PE/PG		
Regularly participates in professional society meetings/conferences/workshops/publications (USSD, ASDSO, or similar)		Yes	Yes, typically a member	Yes, typically a technical committee member	Yes, typically a technical committee member	Yes, typically a member		

R – Strongly Recommended

Risk Methodology



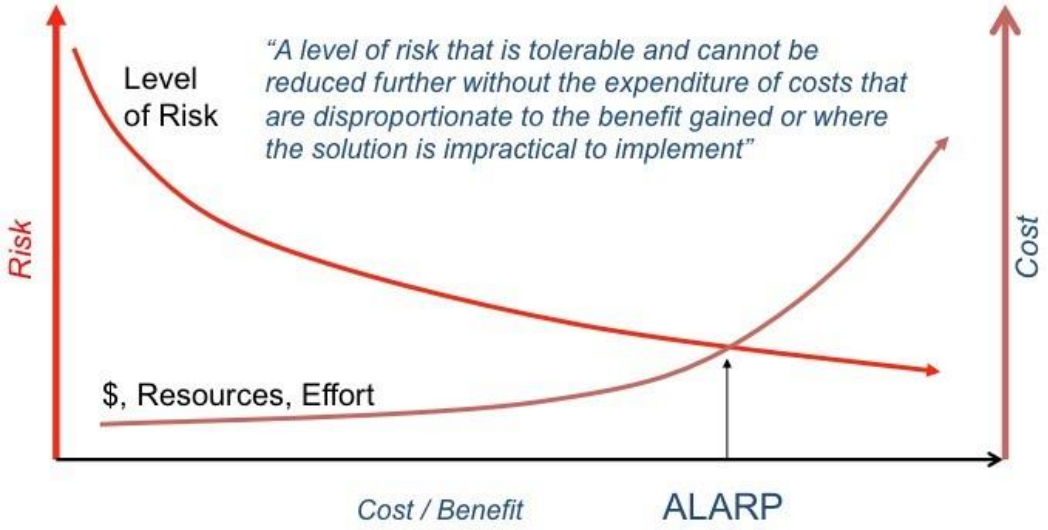
Best Practices in Dam And Levee Safety Risk Analysis

A Joint Publication by
U.S. Department of the Interior, Bureau of Reclamation, and
U.S. Army Corps of Engineers

This manual was developed for internal use. The agencies make no guarantees as to the accuracy or applicability of the information presented herein.

As Low As Reasonably Practicable

- That principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if the next increment of risk reduction is not cost effective compared to the improvement gained. (ICOLD, 2005)



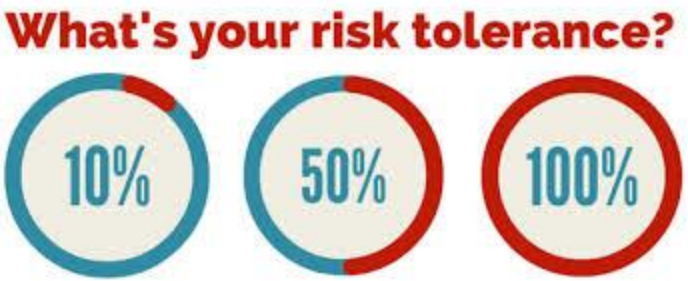
ALARP Factors

1. Cost Effectiveness
2. Level of Risk
3. Disproportionality
4. Good Practice
5. Societal Concerns
6. Other Factors

"One accepts options, not risk"

Chapter 3 – Risk Assessment

- Tolerable Risk Concepts
- Risk Assessment Guidelines
- ALARP Assessment
- Decision Making



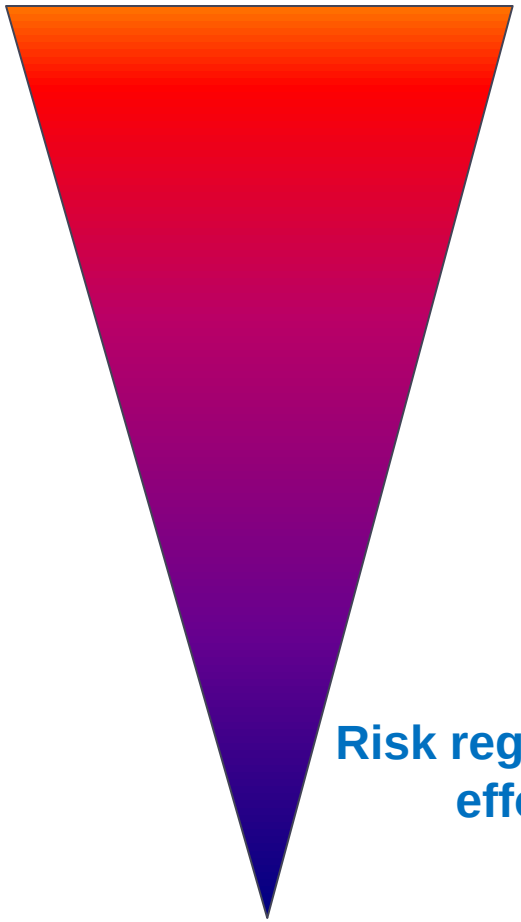
Tolerable Risk Defined

- Tolerable Risk is (by the International Committee on Large Dams (2005) adapted from HSE (2001)):
  1) Risk society is willing to live with so as to secure certain benefits,
  2) Risk society does not regard as negligible or something it might ignore,
  3) Risk that society is confident that are being properly managed by the owner,
  4) Risk the owner keeps under review AND
  5) Reduces still further as practicable.

UK Health & Safety Executive (2001) Tolerability of Risk Framework

Unacceptable Region

Risks cannot be justified except in extraordinary circumstances



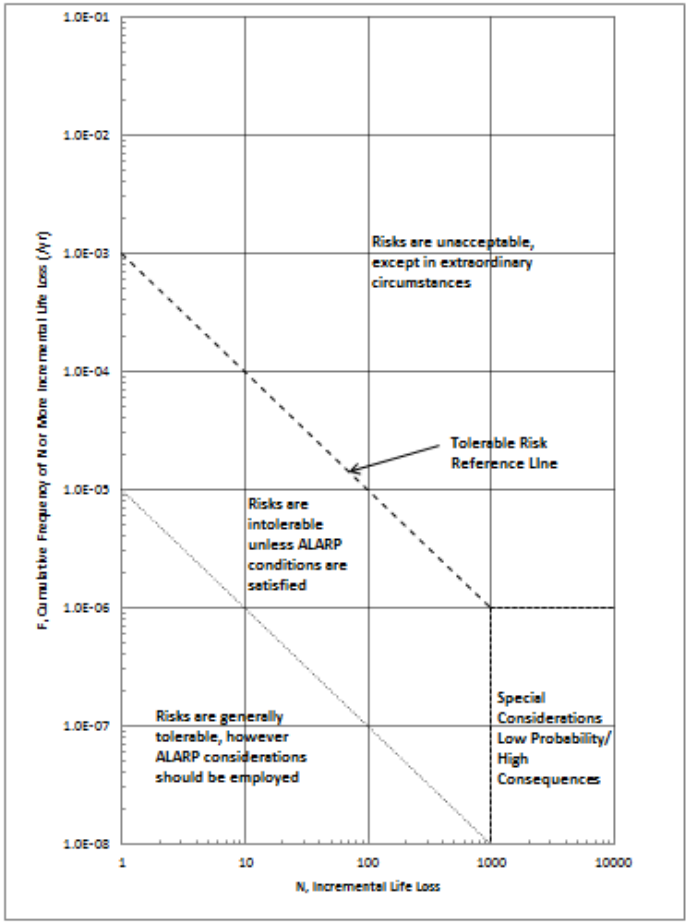
Tolerable Region

In this region, risks must be controlled; ALARP measures must be introduced to drive residual risks towards the broadly acceptable region

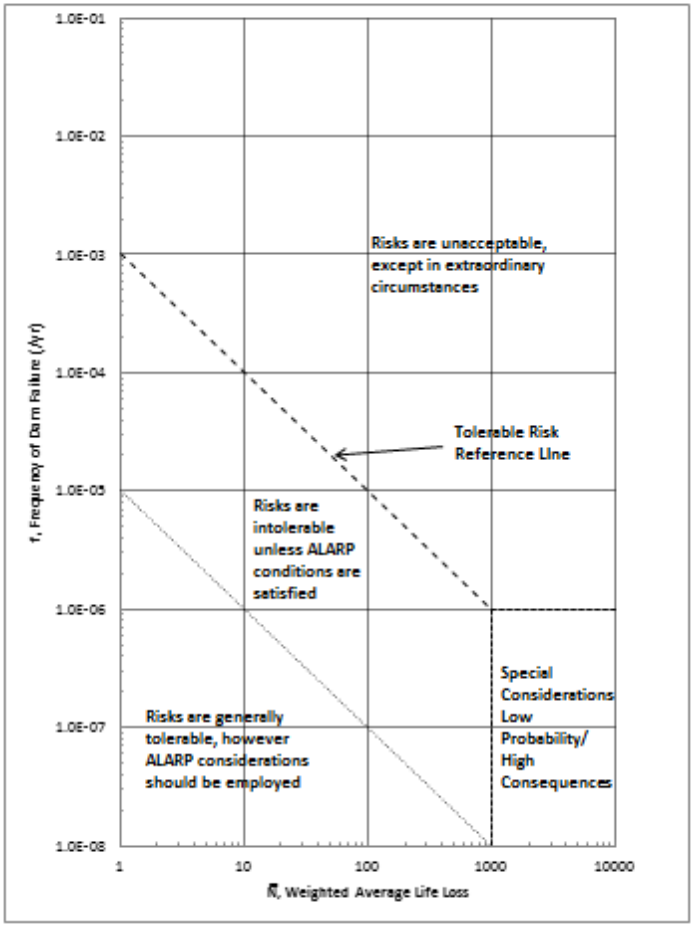
Broadly Acceptable Region

Risk regarded as insignificant, further effort to reduce risk not required unless easily achieved

F-N


1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
F, Cumulative Frequency of Nor More Incremental Life Loss (/yr)
Risks are unacceptable, except in extraordinary circumstances
Tolerable Risk Reference LIne
Risks are intolerable unless ALARP conditions are satisfied
Risks are generally tolerable, however ALARP considerations should be employed
Special Considerations Low Probability/ High Consequences
1
10
100
1000
10000
N, Incremental Life Loss

f-N

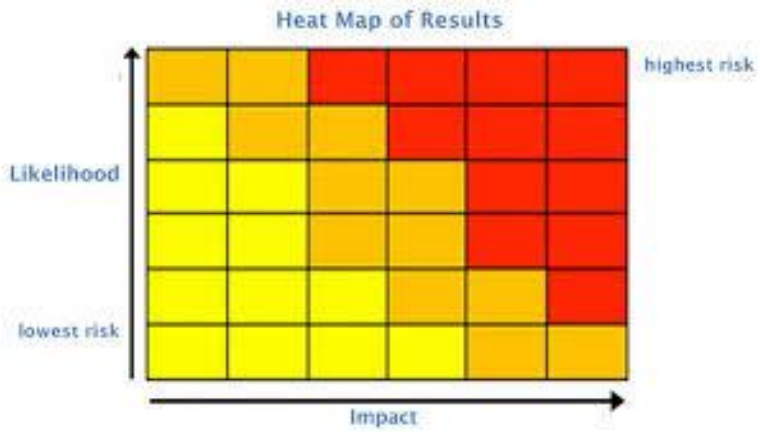

1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
f, Frequency of Dam Failure (/yr)
Risks are unacceptable, except in extraordinary circumstances
Tolerable Risk Reference LIne
Risks are intolerable unless ALARP conditions are satisfied
Risks are generally tolerable, however ALARP considerations should be employed
Special Considerations Low Probability/ High Consequences
1
10
100
1000
10000
N̄, Weighted Average Life Loss

Building the Case

- Are Risks Tolerable?
  - ALARP
- Risk Estimate
- Uncertainty
- Confidence

Chapter 4 – Risk Management

- Risk Management
  - Prioritization
- Risk Reduction Measures
- Risk Communication



Dam Safety Risk Classification (DSRC)

Urgency of Action (DSRC)	Description	Characteristics	Potential Actions
I – VERY HIGH	An active potential failure mode is in process or the likelihood of a failure is judged to be extremely high, such that immediate actions are necessary to reduce risk.	**CRITICALLY NEAR FAILURE**: There is direct evidence that failure is in progress, and the dam is almost certain to fail during normal operations if action is not taken quickly. OR **EXTREMELY HIGH RISK**: Combination of life or economic consequences and likelihood of failure is very high with high confidence.	• Take immediate action to avoid failure • Communicate findings to potentially affected parties • Implement IRRMs, including operational restrictions • Ensure that the EAP is current and functionally tested for initiating event • Conduct heightened monitoring and evaluation • Expedite investigations and actions to support long-term risk reduction • Initiate intensive management and situation reports
II – HIGH	Potential failure mode(s) are judged to present very serious risks, either due to a very high probability of failure or due to very high life loss, that justify an urgency in actions to reduce risk.	**RISK IS HIGH WITH HIGH CONFIDENCE, OR IT IS VERY HIGH WITH LOW TO VERY LOW CONFIDENCE**: Failure could begin during normal operations or be initiated as a result of an event. The likelihood of failure from one of these occurrences, prior to taking some action, is too high to delay action.	• Communicate findings to potentially affected parties • Implement IRRMs, including operational restrictions, as warranted • Ensure that the EAP is current and functionally tested for initiating event • Conduct heightened monitoring and evaluation • Expedite investigations and actions to support long-term risk reduction • Expedite confirmation of classification
III – MODERATE	Potential failure mode(s) appear to be dam safety deficiencies that pose a significant risk of failure and actions are needed to better define risks or to reduce risks.	**MODERATE TO HIGH RISK**: Confidence in the risk estimates is generally at least moderate, but can include facilities with low confidence if there is a reasonable chance that risk estimates will be confirmed or potentially increase with further study.	• Implement IRRMs, including operational restrictions, as warranted • Ensure that the EAP is current and functionally tested • Conduct heightened monitoring and evaluation • Prioritize investigations and actions to support long-term risk reduction • Prioritize confirmation of classification as appropriate
IV – LOW	Potential failure mode(s) appear to indicate a potential concern, but do not indicate a pressing need for action.	**LOW RISK**: The risks are low to moderate with at least moderate confidence, or the risks are low with low confidence, and there is a potential for the risks to increase with further study.	• Ensure that routine risk management measures are in place • Determine whether action can wait until after the next Part 12D Report • Before the next Part 12D Report, take appropriate interim measures and schedule other actions as appropriate • Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time
V – NO	Potential failure mode(s) do not appear to present significant risks and there are no apparent dam safety deficiencies.	**VERY LOW RISK**: The risks are low to very low and are unlikely to change with additional investigations or studies.	• Continue routine dam safety risk management activities and normal operations and maintenance

Chapter 4 – Risk Management

- Interim Risk Reduction Measures
  - Plan Requirements
  - Submittal Requirements (DSRC I, II, III)
- Routine Dam Safety Activities
  - Inspections
  - EAPs
    - Exercise frequency based on DSRC
  - DSSMP/R
- Risk Communication Plan

Path Forward

- Internal video conferences — April
- External webinars (licensees and consultants) — May

Pilot Studies

- The purposes of the risk pilot studies are to:
  - Provide a clearer understanding of the outstanding dam safety issues at each dam and provide a more confident path to resolution of those issues through risk-informed decision making.
  - Evaluate the RIDM policy and processes, including identifying potential shortcomings in the interim guidelines.

Ahead

- Level 1 risk analysis review/update
- Pilot risk analyses (Level 3 and 4)
- Level 2 risk analysis methodology development
  - Trial studies in spring 2017
- Training plan and schedule

Level 2 RA

- During Part 12D Consultant's Inspection
- Trial Studies starting 2017
- Extension of PFMA
- Low Level of Effort
- Provides an Initial Estimate of Risk

Training

- Internal
  - HQ/RIDM Branch
  - Regional Staff
- External
  - Licensees
  - Consultants
  - Others


Any questions?